respectively. There were no strict regulations for the subjects to follow. However, the final datasets were chosen based on the most difficult fingers according to quality index [27].

4.3 Database Comparison

Even though there are many other existing fingerprint databases, these databases differ from one another. Among all the databases as explained in the previous sections, CASIA-FingerprintV5 has the largest number of subjects and fingerprint images. However, there were only five samples per finger for each subject. The FVC has conducted four fingerprint verification competitions in four different years. Each year, they collected four new fingerprint databases. In all four databases, they had collected the same amount of fingerprint images using different type of sensors.

In comparison, our database, i.e., FingerDOS, was acquired using an optical sensor as explained in the previous section. Compared to the other databases, our database has more number of fingerprint samples per finger with minimal finger displacement on the sensor plate. Table 2 gives a number of characteristics for the stated databases.

4 Conclusion

In this paper, a new fingerprint database has been presented. This fingerprint database is using one of the most common fingerprint sensors, i.e., optical sensor. Some of the reasons in using this kind of sensor are because, it is cheaper and produces a better quality of fingerprint images compared to other sensors. There were 60 subjects involved in the acquisition of fingerprint images.

Although there are many other fingerprint databases available publicly, most of them were collected with finger displacement on the sensor plate. The inconsistency made the fingerprints hard to be recognized and causes the recognition rate becomes lower.

One of the advantages of our fingerprint database is, it has less fingerprint displacement which makes it easier to conduct recognition. Besides, this fingerprint database also has a wide number of fingerprint samples, i.e., 10 samples per finger. Online description and request of the database are available to the public at http://www.fingerdos. wordpress.com.

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References:

[1] Biometrics History, p. 5, *National Science and Technology Council (NSTC)*. Retrieved Mar. 30, 2014, from http://www.biometrics.gov/ ReferenceRoom/Introduction.aspx.

[2] F. Galton, *Finger Prints*, Macmillan, London, 1982.

[3] J. G. Barnes, "History" in *The Fingerprints Source Book*, Washington, DC, 2004, ch. 1, p. 11. [E-book] Available: NCJRS.

[4] L. A. Hutchins, "Systems of friction ridge classification," in *The Fingerprint Source Book*, Washington, DC, 2004, ch. 5, pp. 22-23. [E-book] Available: NCJRS.

[5] K. R Moses, P. Higgins, M. McCabr, *et al.*, "Automated fingerprint identification system (AFIS)," in *The Fingerprint Source Book*, Washington, DC, 2004, ch. 6, pp. 22-23. [E-book] Available: NCJRS.

[6] S. Pankanti, S. Prabhakar, and A. K. Janin, "On the individuality of fingerprints," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol.24, No.8, pp. 1010-1025, Aug. 2002.

[7] CASIA-FingerprintV5 Database. Retrieved Apr. 10, 2014, from http://www.idealtest.org/.

[8] Fingerprint Verification Contest 2000; FVC2000. Retrived Apr. 10, 2014 from http://bias.csr.unibo.it/fvc2000.

[9] Fingerprint Verification Contest 2002; FVC2002. Retrieved Apr. 10, 2014, from http://bias.csr.unibo.it/fvc2002.

[10] Fingerprint Verification Contest 2004; FVC2004. Retrieved Apr. 10, 2014, from http://bias.csr.unibo.it/fvc2004.

[11] Fingerprint Verification Contest 2006; FVC2006. Retrieved Apr. 10, 2014, from http://bias.csr.unibo.it/fvc2006.

[12] J. Ortega-Garcia, J. Fierrez-Aguilar, D. Simon, J. Gonzalez, M. Faunde-Zanuy, V. Espinosa, A. Satue, I. Hernaez, J. J. Igarza, C. Vivaracho, D. Escudero, and Q. I. Moro, "MCYT baseline corpus: a bimodal biometric database," in *IEE*

Proceedings Vision, Image and Signal Processing, Vol.150, No.6, 2003, pp.395-401.

[13] J. Fierrez, J. Ortega-Garcia, D. Torre-Toledano, and J. Gonzalez-Rodriquez, "BioSec baseline corpus: a multimodal biometric database," *Pattern Recognition*, Vol.40, No.4, pp. 1389-1392, Apr. 2007.

[14] D. Maltoni, D. Maio, A. K. Jain, and S. Prabhakar, *Handbook of Fingerprint Recognition*, Springer, 2003.

[15] F. Alonso-Fernandez, R. Fabio, J. Fierrez and J. Ortego-Garcia, "Comparison of fingerprint quality measures using an optical and capacitive sensor," in *Proceedings of Biometrics: Theory, Applications, and Systems, First IEEE International Conference, BTAS 2007*, Washington, DC, USA, Sept. 2007, pp. 1-6.

[16] A. Ross and A. Jain, "Biometric sensor interoperability: a case study in fingerprints," in *Proceedings of International ECCV Workshop on Biometric Authentication (BioAW)*, Vol.3087, May 2004, pp. 134-145.

[17] K. Alagar and A Subbanna, "Combined SIQT and SSF matching score for feature extraction evaluation in finger knuckle print recognition," *WSEAS Transactions on Computer*, Vol.12, No.10, pp. 384-394, Oct. 2013.

[18] E. Lim, K. Toh, P. Suganthan, X. Jiang and W. Yau, "Fingerprint image quality analysis," in *International Conference on Image Processing (ICIP 2004)*, Vol.2, Oct. 2004, pp. 1241-1244.

[19] S. Szénási, Z. Vámossy, and M. Kozlovszky, "Evaluation and comparison of cell nuclei detection algorithms," in *16th International Conference on Intelligent Engineering Systems (INES 2012)*, 2012, pp. 469-475.

[20] Z. Kerekes, Z. Toth, S. Szénási, Z. Vámossy, and Sz. Sergyan, "Colon cancer diagnosis on digital tissue images," in *Proceedings of IEEE 9th International Conference on Computational Cybernatics*, 2013, pp. 159-163.

[21] SecuGen Biometric Solutions Datasheets. Retrieved Mar. 15, 2014, from http:// www.secugen.com/download/datasheets.htm.

[22] J. Fierrez, J. Galbally, J. Ortega-Garcia, M. R. Freire, F. Alonso-Fernandez, *et al.*, "BiosecureID: a multimodal biometric database," *Pattern Analysis and Applic*ations, Vol.13, No.2, pp. 235-246, May 2010.

[23] A. Annis Fathima, S. Vasuhi, Teena Mary Treesa, N. T. Naresh Babu, and V. Vaidehi, "Person authentication system with quality analysis of multimodal biometrics," *WSEAS Transactions on Information Science and Applications*, Vol.10, No.6, pp. 180-194, June 2013.

[24] Integrated Automated Fingerprint Identification System; IAFIS. Retrieved Apr. 10, 2014, from http://www.fbi.gov/about-us/cjis/fingerprints_biometrics/iafis/iafis.

[25] F. Alonso-Fernandez, J. Bigun, J. Fierrez, H. Fronthaler, K. Kollreider, and J. Ortego-Garcia, "Fingerprint recognition," in *Guide to Biometric Reference Systems and Performance Evaluation*, Springer London, 2009, ch. 4, pp. 51-88. [E-book] Available: SpringerLink.

[26] M. R. Ramlan, D. B. L. Bong, and T. Z. Lee, "Analysis of thumbprint recognition in different bit levels," in *Proceedings-2012 International Conference on Advanced Computer Science Applications and Technologies, ASCAT 2012*, 2012, pp. 192-196.

[27] D. Maio and D. Maltoni, "Direct gray-scale minutiae detection in fingerprints," *IEEE Transactions Pattern Analysis and Machine Intelligence*, Vol.19, No.1, pp. 27-40, 1997.